8 Standards in Process Control and Automation

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The term "standard" has many definitions. The Oxford English dictionary defines *standard* as "**noun:** (1) a level of quality or attainment, (2) a required or agreed level of quality or attainment, and (3) something used as a measure, norm, or model in comparative evaluations. **Adjective:** (1) used or accepted as normal or average, and (2) regularly used or produced such as of a size, measure, etc."

From these definitions, in context of process control the word "standard" implies comparative evaluations of physical quantities, processes, and procedures.

Standards in industrial organizations are practiced in a number of ways:

- The fundamental physical standards
- Published standards (also termed as the Paper standards) that are published by national and international standardization organizations and are available for anyone to use
- De facto standards that are followed by convention or popular use
- De Jure standards that are part of legally binding contracts, laws, or regulations

In this article, primarily, the paper (or published) standards will be discussed. Structural and operational procedures of selected national and international standardization organizations will be explained. Some examples related to industrial processes and networks will be given.

BACKGROUND

In this chapter, the fundamental standards will lightly be touched if and when the needed but published standards relevant to the industrial processes, automation, and networks will be explained in detail. Published standards are important documents that provide textual and illustrative information on what and how the processes and practices should be performed to achieve a particular task. The National Standards Policy Advisory Committee (http://www.nist.gov/) describes a standard as "a prescribed set of rules, conditions, or requirements concerning definitions of terms: classification of components; specification of materials, performance, or operations; delineation of procedures; or measurement of quantity and quality in describing materials, products, systems, services, or practices."

Published standards are necessary for worldwide trading, business practices, production of goods, manufacturing, scientific investigations, and research and development. They ensure consistency in implementation and interpenetration of different technologies in different organizations and sectors. Because of the national and international implications, there are many institutions that are responsible for developing, investigating, and maintaining the relevant standards to support worldwide scientific, commercial, and industrial activities.

Despite the importance of consistent and uniform standards, national and international authorities are subject to various internal and external forces, differences of expertise and opinions, as well as commercial interests. Therefore, during the development of the standards the final outcome may not always be the desired ideal case. This, unfortunately, may result in a confusing number of standards with different versions and interpretations of a specific process, artifact, or measurement. In addition, publications grow over the time as the new technological developments take place, and the standards authorities change internally, hence the procedures and practices may change over time not necessarily for the best outcome. Therefore, when selecting and applying a particular standard care must be taken for its national and international validity at the present and in the future. In this chapter, we intend to shed some light on these concerns.

STANDARDS ORGANIZATIONS

Standards are formulated by standards development organizations (SDOs). These organizations can be government agencies, professional societies, international or regional organizations, private companies, or trade associations. World standard organizations can be categorized in four major groups as national, international, consortium, and industry organizations, illustrated in Figure 8.1.

Each organization has various branches that are responsible for a particular area. As an example, Figure 8.2 illustrates some important branches of American National Standards Institute. A partial list of national and international standards

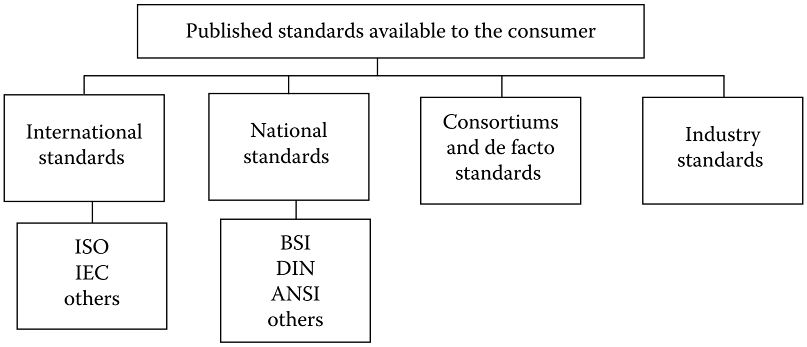

FIG. 8.1
World standards organizations.

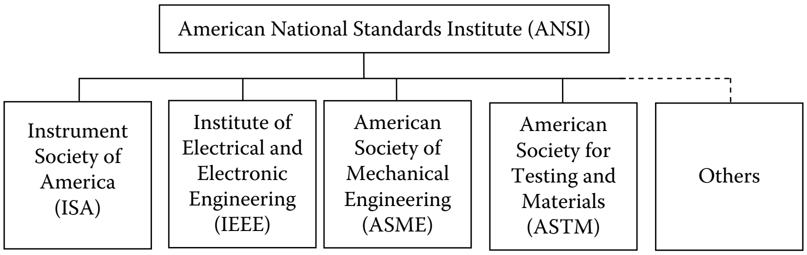
American National Standards Institute (ANSI)
Instrument Society of America (ISA)
Institute of Electrical and Electronic Engineering (IEEE)
American Society of Mechanical Engineering (ASME)
American Society for Testing and Materials (ASTM)
Others

FIG. 8.2
Branches of the American National Standards Institute.

TABLE 8.1
Partial List of National and International Standard Organizations

Acronym	*Organization Name and Web Address*
ANSI	American National Standards Institute (http://www.ansi.org/)
AFNOR	Association Française de Normalization (http://www.afnor.fr/)
BSI	British Standards Institution (http://www.bsi-global.com/)
CEI	Comitato Elettrotecnico Italiano (http://www.ceiuni.it/)
CEN	Comité Européen de Normalisation (http://www.cenorm.be/)
CENELEC	Comité Européen de Normalisation Electrotechnique (http://www.cenelec.be/)
CSSN	China Standards Information Center (http://www.cssn.net.cn/)
DIN	Deutsches Institut für Normung (http://www2.din.de/)
IBN	The Belgian Institution for Standardization (http://www.ibn.be/)
IEC	International Electrotechnical Commission (http://www.iec.ch/)
ISO	International Organization for Standardization (http://www.iso.org/)
JISC	Japan Industrial Standards Committee (http://www.jisc.go.jp/)
KATS	Korean Agency for Technology and Standards (http://www.ats.go.kr/)
NIST	American National Standards and Technology (http://www.nist.gov/)
ASI	Austrian Standards Institute (http://www.on-norm.at/)
SA	Standards Australia (http://www.standards.com.au/)
SCC	Standards Council of Canada (http://www.scc.ca/)
SII	The Standards Institution of Israel (http://www.sii.org.il/)
NZS	Standards New Zealand (http://www.standards.co.nz/)
TSE	Türk Standardlari Enstitüsü (http://www.tse.org.tr/)

organizations that deal with published standards are given in Table 8.1.

Each national and international organization have several specialist groups that encompass a broad range of scientific disciplines such as the process control, safety, installations, electromagnetic, temperature, chemical, mechanical, radiation, optical standards, and so on.

Common to all organizations general terminology, vocabulary, and definitions concerning standardization and related activities are determined. This acts as an agent to develop a mutual understanding amongst the members, groups, and concerned parties at individual, governmental, and organizational levels. The aim is that these standards are prepared in such a manner that they can be understood, used, and referred to easily. To stimulate this, standards organizations have strict guidelines to assist technical groups and committees in drafting and producing the standards. A typical preparation process has two main stages:

- *Preliminary work* that includes overall analysis, identification of target groups, determination of subject delimitation, finding the relevant sources, determining the affecting concepts, choosing the languages, working out the schedules, etc.
- *Working procedure* that includes collecting and recording terminological data, establishing the term list, determining the concept fields and concept systems, formulating definitions, establishing and structuring the entries, order of entries, indexes, graphic representation, bibliography, and so on.

In many cases, the standards are produced by various bodies, sometimes operating totally independent from each other. Hence, there may be different versions for the same subject. However, there are a number of international standards organizations such as the International Organization of Standardization (ISO) and the International Electrotechnical Commission (IEC) representing many countries. As explained above, these organizations have multiple internal departments, international committees, subcommittees, and working groups to support their activities.

Links of Standards Organizations

Standards are important for scientific, research and development activities and international trade therefore there is continuous links and cooperation between national, regional, and international organizations. For example, in the case of ISO, there are many affiliated standards organizations, which represent countries. The membership structure is as follows:

1. *Full members* are national bodies that are entitled to participate and exercise full voting rights on any technical committee and policy committee of the ISO.
2. *Correspondent members* that do not take an active part in the technical and policy development, but are entitled to be kept fully informed about their work of interest. These are countries that do not have their own standards organization.
3. *Subscriber members* that represent the countries with small economies. The membership fees of the subscriber members are reduced but are allowed to be represented in some committees.

Apart from the international organizations that are made up with voting and non-voting members, there are also numerous other mechanisms that maintain links between standard institutions and organizations. Examples are as follows:

- *The Asia-Pacific Legal Metrology Forum* (APLMF) is a grouping of legal metrology authorities in the Asia-Pacific Economic Cooperation (APEC). The objective of this forum is the development of legal metrology and the promotion of free and open trade in the region through the harmonization and removal of technical or administrative barriers.
- *Bureau International des Poids et Mesures* (BIPM) that ensure worldwide uniformity of measurements and their traceability to the International System of Units (SI).
- *World Trade Organization* (WTO) is an international agency whose purpose is to help trade flow as smoothly as possible in a system based on rules, to settle trade disputes between governments, and to organize related negotiation.
- *Joint Technical Committees* are formed to deal with the consequences of substantial overlap in areas of standardization and work related to information technology. For example, IEC has formed a Joint Technical Committee known as the ISO/IEC JTC1 was the first such joint committee and it is still fully functional.

Many standards organizations collaborate as consortiums to develop and implement particular standards, as in the case of fieldbus systems for industrial digital information transmissions and applications. The development of standards is a complex procedure involving many groups at the national, international, and organizational levels. Some examples will be provided in the next section.

DEVELOPMENT OF STANDARDS

SDOs undertake the task of producing relevant standards in their expertise areas. There are many different national and international SDOs; some of these organizations are

- National Electrical Manufactures Association (NEMA) (http://www.nema.org/)
- National Institute of Standards and Technology (NIST) (http://www.nist.gov/index.html), etc.

At the individual organization level, they have different ways of developing standards depending on their structures and sizes. Here, the ISO will be given as an example of a typical body. More information can be found on ISO website (http://www.iso.org/) and indeed on the websites of many other organizations.

International Standards Organization

The ISO plays an important role in development and proliferation of standards in process industry and automation.

It is one of the largest of the standards organizations with 96 full member countries and 161 national members. It is a non-government organization but sets standards such that many become laws either through treaties or national standards. Therefore, here, further explanation will be provided and more information can be found at (http://www.iso.org/).

ISO promulgates worldwide proprietary industrial and commercial standards. It produces international standards as well as publishing technical reports, technical specifications, technical corrigenda, and guides as explained in the following.

One of the products of the ISO is the *technical reports*. Technical reports are products of technical committees or subcommittees after having collected substantial data on a topic. These reports normally lead to the development of international standards and they are identified with *TR* on their titles. Some examples are

- ISO/TR 19033:2000 Technical product documentation—Metadata for construction documentation
- SO/IEC TR 17799:2000 Code of Practice for Information Security Management

ISO also publishes *technical specifications* and *publicly available specifications* as intermediate information before the development full international standard on a particular subject. Technical specifications are identified with *TS*, for example,

- ISO/TS 16952-1:2006 Technical product documentation—Reference designation system—Part 1: General application rules
- ISO/PAS 11154:2006 Road vehicles—Roof load carriers

ISO also issues *technical corrigendum*, which are amendments to existing standards because of minor technical flaws, improvements, or extend applicability in a limited way. Generally, technical corrigendum is issued with the expectation that the affected standard will be updated or withdrawn at its next review.

ISO *guides* are produced as meta-standards. They cover guides and rules for matters related to international standardization efforts, for example:

- ISO/IEC Guide 2:2004 Standardization and related activities—General vocabulary
- ISO/IEC Guide 65:1996 General requirements for bodies operating product certification

In order to understand how ISO develops standards, it is important to look at its organizational structure.

Structure of ISO

The ISO operates with the following committees and groups:

- *Policy development committees* that are established by the General Assembly to draft policies. The committees are open to all full member and correspondent members, and they directly report to the council. Policy development committees have several branches such as the Committee on conformity assessment, Committee on consumer policy, etc.
- *Council* that operates the ISO. It consists of 18 elected representatives of full members and some permanent officers.
- *Council standing committees* that advises the Council on policy and strategic matters, and raises any related issues.
- *Technical management board* that examines proposals, monitors the work of technical committees, establishes and dissolves technical advisory groups.
- *Technical Advisory Groups* (TAGs) that advise the Board on basic, sectoral, and cross-sectoral coordination, coherent planning, and the needs for new work. For example, TAG 4 is responsible for metrology matters.
- *Technical committees* that is responsible with a particular area such as TC 12 for quantities, units, symbols, conversion factors; TC 108 mechanical vibration and shock; etc.
- *Ad hoc advisory groups* that recommend standardizations.

The standards are developed according to the following principles:

- *Consensus*: The views of all interests manufacturers, vendors, users, consumer groups, testing laboratories, governments, engineering professionals, and research organizations are taken into account.
- *Industrywide*: Solutions intend to satisfy industries and customers worldwide.
- *Voluntary*: International standardization is market driven and therefore based on voluntary involvement of all interests in the marketplace.

There are three main phases in the standards development process, which can be explained as follows:

1. The need for a standard is usually expressed by an industry sector, which communicates this need to a national member body. The latter proposes the new work item to ISO as a whole. Once the need for an International Standard has been recognized and formally agreed, the first phase involves definition of the technical scope of the future standard. This phase is

usually carried out in working groups which comprise technical experts from countries interested in the subject matter.
2. Once agreement has been reached on which technical aspects are to be covered in the standard, a second phase is entered during which countries negotiate the detailed specifications within the standard. This is the consensus-building phase.
3. The final phase comprises the formal approval of the resulting draft International Standard (the acceptance criteria stipulate approval by two-thirds of the ISO members that have participated actively in the standards development process, and approval by 75% of all members that vote), following which the agreed text is published as an ISO International Standard.

A normal procedure is that the standards to be internationalized can be brought to the attention of the ISO form a country or industry or business through one or more of the member organizations. The members propose the new work item to the ISO as a whole. If accepted, the work item is assigned to an existing technical committee. The technical committees are comprised from experts appointed from industrial, technical and business sectors. These experts may be joined by others with relevant knowledge, such as representatives of government agencies, testing laboratories, consumer associations, environmentalists, and so on. Generally, the experts are selected from the national delegations nominated by the member institutes of the countries concerned. The ISO rules states that the member institutions are expected to take account of the views of a broad range of interested parties and other stakeholders so that acceptance of the proposal becomes a consolidated in a consensus manner.

The national delegations of experts of a technical committee meet to discuss and debate until a consensus is reached on a draft agreement. The draft agreement is then circulated as a Draft International Standard (DIS) to members for comments and balloting. Members are responsible for providing public review procedures for making draft standards known and available to interested parties as well as to the general public. Once the feedback is received from members, the draft standard is formulated in its final form to be voted by the members. If the voting is in favor, the document, with eventual modifications, is circulated to the ISO members as a Final Draft International Standard (FDIS). If that vote is positive again, the document is then published as an International Standard.

Most standards require periodic revision as several factors combine to render a standard out of date: technological evolution, new methods and materials, new quality and safety requirements. To take account of these factors, ISO has established the general rule that all ISO standards should be reviewed at intervals of not more than 5 years. On occasion, it is necessary to revise a standard earlier.

Similar processes take place in other organizations depending on their internal cultures and structures. For example, in the case of the IEC, there are seven stages to develop a full standard document (http://www.iec.org/):

1. Proposal stage—New work item proposal (NP)
2. Preparatory stage—Working draft(s) (WD)
3. Committee stage—Committee drafts (CD)
4. Inquiry stage—Inquiry draft (DIS, CDV)
5. Approval stage (FDIS-Final draft int. std)
6. Publication stage
7. If FDIS fails, the Technical Report 2 (TR2) is published and revised after 2 years

TR2 status means: Publication of work is still under technical development, or for any other reason there is a future prospect but not immediate possibility of agreement.

Obtaining ISO Standards

ISO documents are copyrighted and ISO charges for copies of most. ISO does not charge for most draft copies of documents in electronic format. Although useful, care must be taken using these drafts since there is the possibility of substantial change before it becomes finalized as a standard. Some standards by ISO and its official U.S. representative (and the International Electrotechnical Commission's via the U.S. National Committee) are made freely available.

Many of the ISO standards are ubiquitous, which has led to the common use of "ISO" to describe the actual product that conforms to a standard. Some examples of this are

- ISO 9660 standard filesystem has been adopted by many organizations hence the CD images are commonly referred to as "ISOs." Almost all computers with CD-ROM drives can read CDs that use this standard. Some DVD-ROMs also use ISO 9660 file systems.
- ISO 5800:1987 on photographic film's sensitivity to light and its film speed is often referred to as its "ISO number."

OBTAINING STANDARDS

There are several hundred thousand standards and technical regulations in the world containing special requirements for a particular industry, country, or region. Finding relevant information on the specific standards can be a difficult task. Nevertheless, once the standard is identified for a particular application, it can be obtained in paper or electronic forms from various sources. For example, standards can be purchased online from standards institution or other providers using their catalogs. Some of the websites that provide full-text standards are given below, but the list is not exhaustive.

- ETSI, European Telecommunications Standards Institute, offers direct access to publicly available ETSI telecommunications standards (http://www.etsi.org/)
- IAEA, International Atomic Energy Agency, offers most recent IAEA publications online (http://www.iaea.org/)
- IEEE Xplore, Institute of Electrical and Electronics Engineers, offers standards for members (http://ieeexplore.ieee.org/)
- NISO, National Information Standards Organization, offers free full text access to NISO information standards (http://www.niso.org/)
- ANSI, American National Standards Institute, offers a range of standards for purchasing (http://www.ansi.org/)
- Global Engineering Documents offers national and international standards (http://global.ihs.com/)
- Information Handling Services (HIS), offers most engineering standards (http://www.ihs.com/)
- World Standards Services Networks (WSSN), offers national and international standards (http://www.wssn.net/)
- National Standards Services Networks (NSSN) offers national and international standards (http://www.nssn.org/)

USING THE STANDARDS

Standards in measurement and metrology largely define guidelines for testing methodology, accuracy, and reporting criteria for consistency and accuracy. From guidelines, the necessary instrumentation, procedures, and control processes can be determined and used appropriately for the design, construction, operation, maintenance, installations, safety, and other related areas. The use of standards in the design and the operations offer many advantages, such as

- Improves the communication between the designers and the operators
- Provides practical application of expert knowledge
- Represents accumulated experience thus avoiding ground up starts
- Enhances operability and interoperability thus ensures compatibility
- Sets a benchmark for global applications
- Sets the recognized level of quality
- Increases market access and user acceptance
- Improves communication between peers in industry and other concerned parties
- Provides immediate access to technical resources
- Provides an understanding on the future trends
- Provides consistency in products, and traceability
- Facilitates interchangeability of products and quality assurance
- Ensures safety
- Facilitates migration of products for integrated systems

EXAMPLES OF STANDARDS

As explained above due to the range of standards organizations, interest groups, and diversity on the subject matters there are many standards available worldwide. This sentiment is summarized on the ISO website with the following remarks: "*ISO has developed over* 17,500 *International Standards on a variety of subjects and some* 1,100 *new ISO standards are published every year. The full range of technical fields can be seen from the listing International Standards. Users can browse that listing to find bibliographic information on each standard and, in many cases, a brief abstract. The online ISO Standards listing integrate both the ISO Catalogue of published standards and the ISO Technical program of standards under development.*" (http://www.iso.org/iso/iso_catalogue.htm#)

Some examples of standards relevant to Control and Automation and Networks are given in Table 8.2.

SOFTWARE STANDARDS

Software is a set of instructions for digital systems, programmable devices and computers. It describes computer programs, procedures, and documentation. Software implemented by programming languages like Assembly language, C++, etc. There are two types: the system software and the application software. The system software enables the computer to execute its own internal operations as well as the application programs such as the word processors. System software includes an operating system to interface with hardware to provide the necessary services for applications.

Software is often regarded as anything except the hardware. Software encompasses a wide range of products and technologies, such as programming languages, FPGA configuration, web pages, HTML, Microsoft Word, etc. running under operating systems such as Linux and Microsoft Windows.

Software has its own niche industry made up of different entities and people. There are many software companies and programmers in the world specialized in certain areas such as mathematic applications, interfacing, automation, robotics, etc. Also, there are many software standard organizations like the W3C, IETF (Internet Engineering Taskforce), and others. These organizations are made up of people by large companies like Microsoft and IBM.

Types of Software Standards

Software standards are certain terms, concepts, and techniques agreed to by software creators. For instance, HTML, TCP/IP, SMTP, POP, and FTP are standards that all software

TABLE 8.2

Partial List of Standards on Control, Automation, and Related Fields

API STD 1164:2009	Pipeline SCADA Security
ANSI/ISA 60079-2009	Electrical Apparatus for Use in Class I, Zone 1 Hazardous
ANSI/ISA 60079-2009	Explosive Atmospheres—Part 6: Equipment Protection
ANSI/ISA 18.2-2009	Management of Alarm Systems for the Process Industries
ANSI/ISA 95-2005	Enterprise-Control System Integration
ANSI/ISA-88 (IEC 61512)	Batch Control Standard
ISA 95	Control and Enterprise Integration Standard
BS EN 62337:2007	Commissioning of Electrical, Instrumentation and Control Systems in the Process Industry
BS 06/30153145	Common Communication Protocol for Generic Linkage on Heterogeneous Networks
BS EN 50173-3:2007	Information Technology. Generic Cabling Systems
BS 09/30198396	BS EN 61784-2. Industrial Communication Networks
BS IEC 62243:2005	Artificial Intelligence Exchange and Service
BS 02/615002	Industrial automation Systems and Integration. Manufacturing Software Capability Profiling
EN 55011:2000	Industrial, Scientific, and Medical RF Equipment
EN 61131-2:2000	Programmable Controllers
IEC 61131-3	PLC Programming Language Standard
IEC 61000	Electromagnetic Compatibility (EMC)
IEC 60079 Parts 1–14	Electrical Installations in Hazardous Areas
IEC 61499	Function Block Standard
IEC 61000-4 Parts 1–30	Testing and Measurement Techniques
IEC 61158- Parts 1–6	Industrial Communication Networks
IEC 61400 Parts 1–25	Wind Turbines
IEC 61784 Parts 1–5	Industrial Communication Networks—Profiles
IEC 62351 Parts 1–6	Power System Control and Associated Communications—Data and Communication Security
IEEE 299:1997	Measuring the Effectiveness of the Shielding Enclosure
ISO ICS 01	Generalities. Terminology. Standardization. Documentation—Graphical Symbols, Technical Drawings, Info, Science
ISO ICS 17	Metrology and Measurement. Physical Phenomena
ISO ICS 19	Testing
ISO ICS 23	Fluid Systems and Components for General Use (Valves, Pumps, Ventilators, and Vacuum technology)
ISO ICS 25	Manufacturing Engineering (Industrial Automation, Machine Tools, Surface Treatment)
ISO ICS 75	Petroleum and Related Technologies
ISO 16100 Parts 1–5	Industrial Automation Systems and Integration
ISO 7700-2:1987	Check of Calibration of Moisture Meters
ISO/IEC 18028-4:2005	Information Technology—Security Techniques—IT Network Security
ISO/IEC 23988:2007	Code of Practice for the Use of Information Technology (IT) in the Delivery of Assessments
ISO/IEC Guide 77-1:2008	Guide for Specification of Product Properties and Classes—Part 1: Fundamental benefits
ISO/IEC Guide 77-2:2008	Guide for Specification of Product Properties and Classes—Part 2: Technical principles and guidance
ISO 3511-1:1977	Process Measurement Control Functions and Instrumentation—Symbolic Representation—Part 1: Basic Requirements

designers must adhere to if the software decides to interface within these standards. Complexity of a standard can vary depending on the type of problem and people involved. A standard is often made to be as simple as possible, maintainable, understandable, and easy to follow.

There are two types of basic software standards:

- *Closed standards:* In which the specifications are kept secret to prevent interference from third parties. It inhibits third-party software from being installed; it keeps third-party hardware from interoperating with it, and it prevents third-party enhancements from improving the product.
- *Open standards:* Specifications for hardware or software that are developed by a standards organization or a consortium involved in supporting a standard. Available to the public for developing compliant products, open standards imply "open systems"; that an existing component in a system can be replaced with that of another vendor. Although many vendors may have contributed to an open standard, and one may have contributed more than others and even have great influence, an open standard is not completely controlled by a single vendor.

Some examples of software standards are given in Table 8.3.

TABLE 8.3

Examples of Software Standards

ISO/CD TS 8000-1	Data Quality—Part 1: Overview, Principles and General Requirements
ISO/TS 8000-100:2009	Data Quality—Part 100: Master Data: Overview
ISO 8000-102:2009	Data Quality—Part 102: Master Data: Exchange of Characteristic Data: Vocabulary
ISO 8000-110:2009	Data Quality—Part 110: Master Data: Exchange of Characteristic Data: Syntax, Semantic Encoding, and Conformance to Data Specification
ISO/TS 8000-120:2009	Data Quality—Part 120: Master Data: Exchange of Characteristic Data: Provenance
ISO/TS 8000-130:2009	Data Quality—Part 130: Master Data: Exchange of Characteristic Data: Accuracy
ISO/TS 8000-140:2009	Data Quality—Part 140: Master Data: Exchange of Characteristic Data: Completeness
ISO 9506-1:2003	Industrial Automation Systems—Manufacturing Message Specification—Part 1: Service Definition
ISO 9506-2:2003	Industrial Automation Systems—Manufacturing Message Specification—Part 2: Protocol Specification
ISO 10303-1:1994	Industrial Automation Systems and Integration—Product Data Representation and Exchange—Part 1: Overview and Fundamental Principles
ISO/PRF TS 29002-20	Industrial automation systems and integration—Exchange of characteristic data—Part 20: Concept dictionary resolution services
ISO/TS 29002-31:2009	Industrial Automation Systems and Integration—Exchange of Characteristic Data—Part 31: Query for Characteristic Data
IEC 62264-1:2003	Enterprise-Control System Integration—Part 1: Models and Terminology
IEC 62264-2:2004	Enterprise-Control System Integration—Part 2: Model Object Attributes
IEC 62264-3:2007	Enterprise-Control System Integration—Part 3: Activity Models of Manufacturing Operations Management

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